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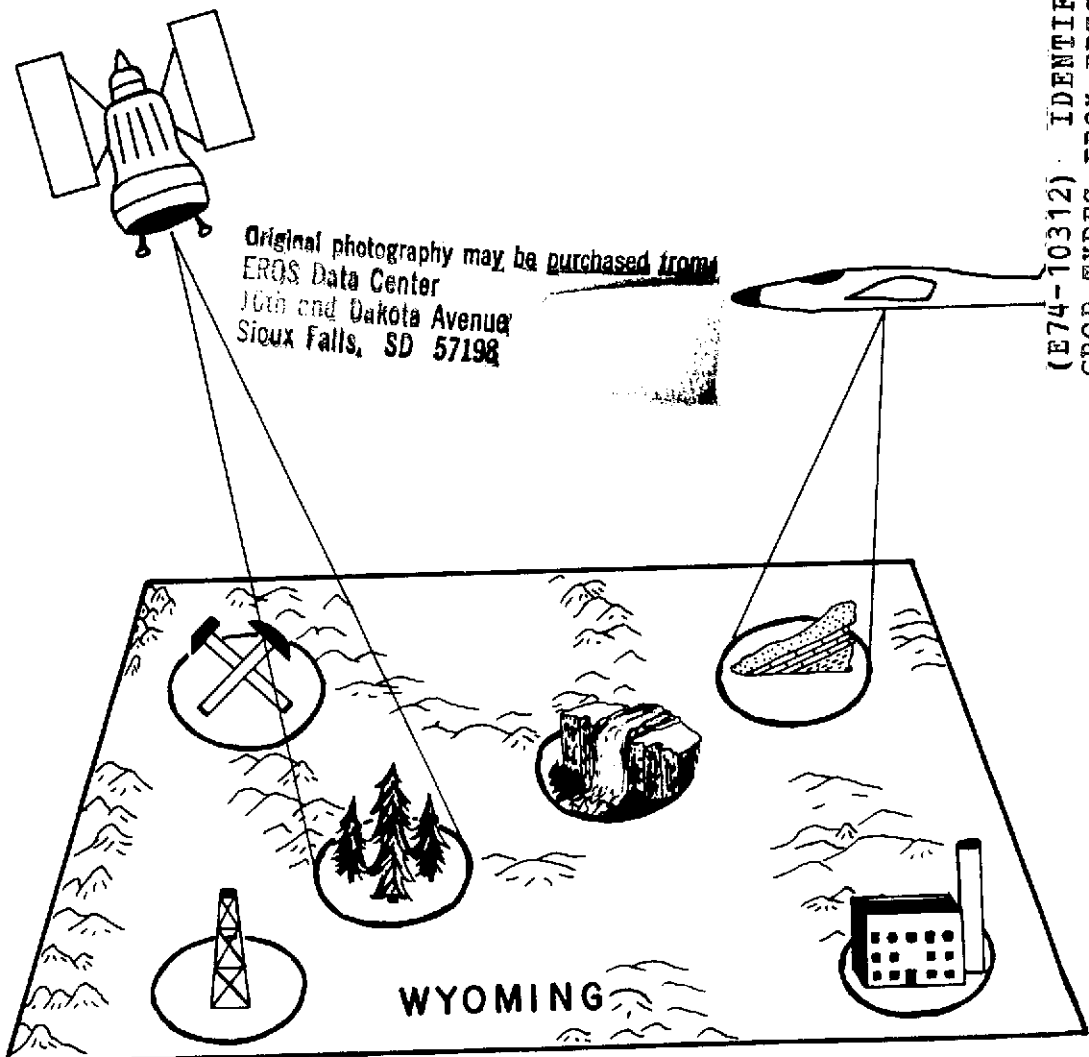
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CROP TYPES FROM ERTS-1 DENSITY CONTOUR  
MAPS AND COLOR INFRARED AERIAL  
PHOTOGRAPHY Special Report (Wyoming  
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IDENTIFICATION OF IRRIGATED CROP TYPES FROM ERTS-1 DENSITY CONTOUR  
MAPS AND COLOR INFRARED PHOTOGRAPHY

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## INTRODUCTION

The use of ERTS-1 imagery for identification and mapping of irrigated and dry-land crops was investigated in an agricultural area north of Wheatland, Wyoming. Initial attempts to identify crop types by direct photointerpretation were only marginally successful. On the other hand, a trained interpreter could readily identify the various crops on 1:120,000-scale color infrared photography of that same area. The contrast apparent from the color infrared aerial photography and the ability of the interpreter to delineate the field patterns on the ERTS imagery suggest that image-enhancement procedures might improve the success of crop-identification from ERTS. The lack of textural information and detail on the ERTS imagery might be compensated by a more accurate estimate of the relative brightness of the fields on the different ERTS bands. Consequently we elected to construct density contour maps of the test area from the ERTS imagery, in an effort to enhance the critical contrasts.

## DESCRIPTION OF THE TEST AREA

The test area is a mixed dry-land/irrigated agricultural area approximately 2- by 2 1/4-mi. in size and located about 4 miles northeast of Wheatland, Wyoming (Figure 1) at the junction of Chugwater Creek and the Laramie River. The major crop types are corn, alfalfa, sugar beets, and grains. The mean elevation of the test area is about 4500' and the mean annual precipitation is 12.45 inches. The soils range in color from grayish brown to dark grayish brown depending on their organic content (Carpenter and others, 1926). The soils of the main cultivated areas are the Laurel loam and the Fort Collins loam while those of the rangeland are chiefly

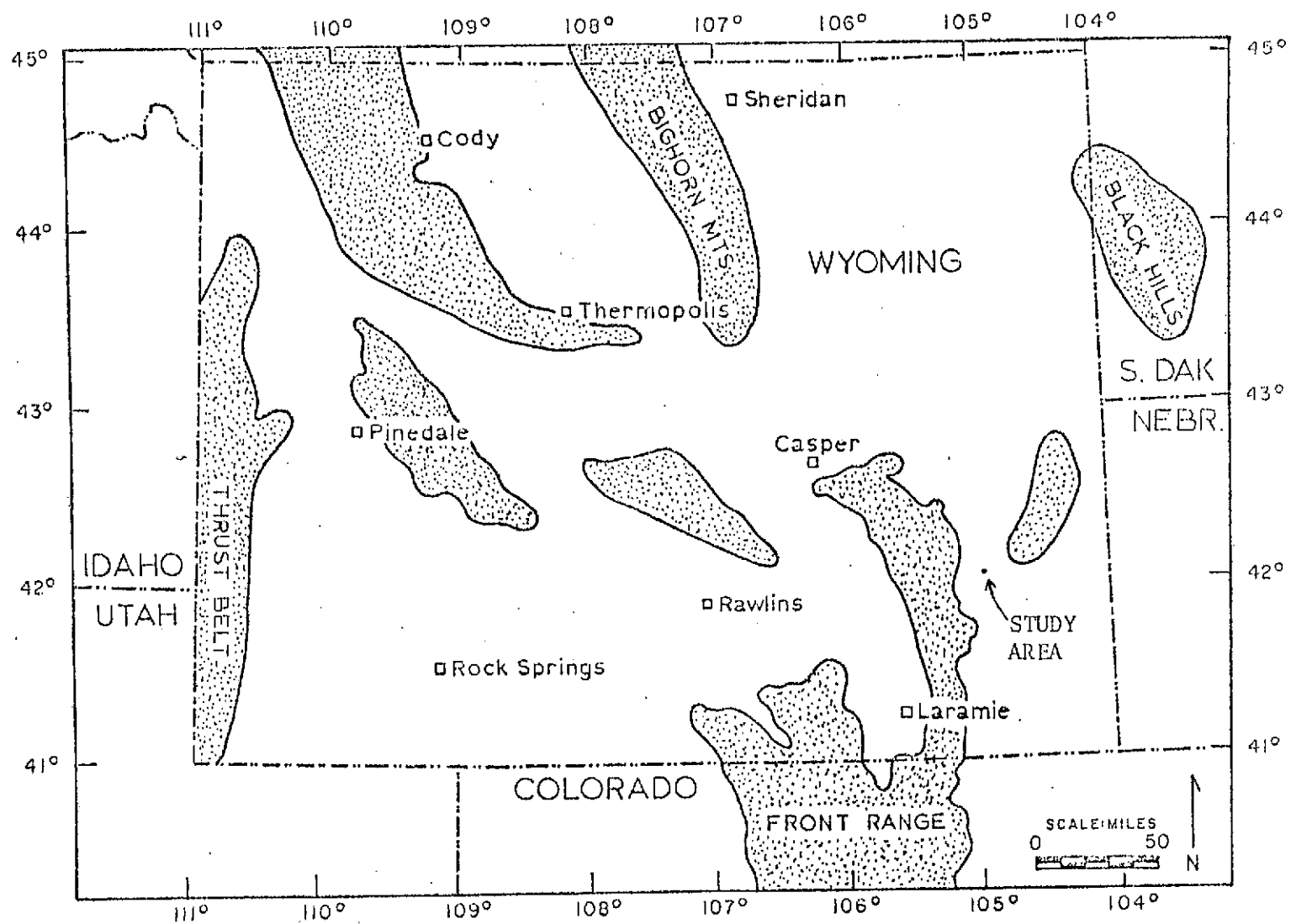


Figure 1. Index map of the study area.

the Dwyer fine sand and the Fort Collins fine sandy loam. The flood-plain soils are various phases of the Laurel, chiefly fine sandy loam and well-drained, fine sand.

The area comprises both irrigated and dry-land farms, rangeland, and heavily-vegetated floodplains. Each of these three major zones is represented by a distinct tone, texture, and pattern which can be readily identified on the ERTS-1 imagery (Figure 2). Further subdivision of the zones is more difficult.

#### INTERPRETATION OF COLOR INFRARED PHOTOGRAPHY

An interpreter who is familiar with the colors, textures, and growth patterns of eastern Wyoming crops can readily train himself to recognize those crops on color infrared photography. Identification of the crops is complicated by variations in the condition of the crops and a certain amount of mixing of crops, such as grain and alfalfa. With sufficient experience, however, the interpreter can learn to deal with these complications and can produce a crop type identification that is 95% correct or better.

Fourteen classes were recognized from the August, 1973 color infrared photography of the test area. They include corn, sugar beets, alfalfa, grains (oats and barley), grain used as a nurse crop for alfalfa, grass/hay and pasture, beans, plowed ground, natural vegetation, natural vegetation supported by irrigation-water runoff, water (ponds and reservoirs), uncultivated floodplain, cultivated floodplain (alfalfa), and farm yards.

On the color infrared photography, corn appears red with an uneven, striated texture. The hue and saturation of the red color depends on the vigor of the corn. Sugar beets show up as a light pink and usually have a very smooth texture. Beets may be confused with corn, but the smoothness

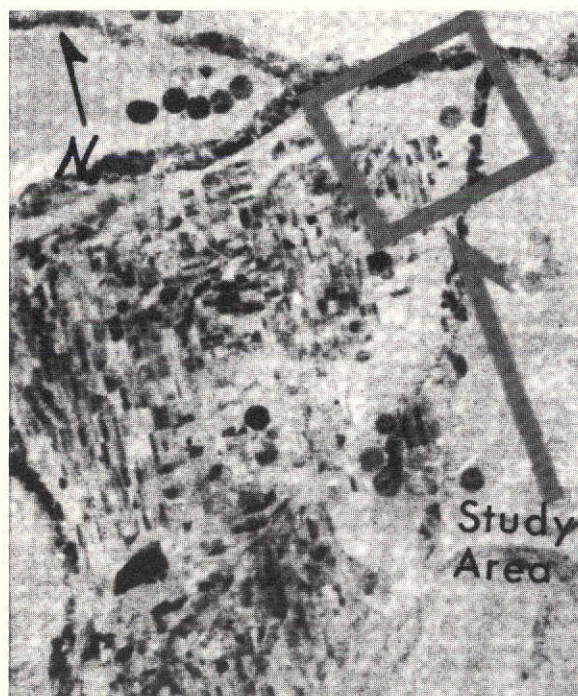


Figure 2. A portion of an enlarged ERTS-1 image, 1352-17132-5, 10 July 1973, showing the Wheatland, Wyoming area and the study area. The scale is 1:160,312.



and characteristic pink color are distinguishable. Standing alfalfa fields are dark red in color and have a smooth texture. Harvested alfalfa fields are various shades of light red and brown, depending on how long ago they were cut. Alfalfa can also be identified by the secondary irrigation ditches running through the field. Grain used as a nurse crop for alfalfa can be distinguished by the faint red color of the young alfalfa plants. Grain fields are a light blue-green in color. In the study area oats and barley were the only grain crops planted. It was not possible to distinguish between the two crop types. Grass/hay used for pasture appears brown to red in color. These areas often have livestock on them and are heavily grazed in the summer. The grazing pressure is reflected in the color of the area, with the brown pastures being in poorer condition or very heavy grazing. Bean fields appear white to gray in color. This may be due to the low plant growth and widely spaced rows.

Plowed or unplanted fields show up as a gray-brown color. Often, if vigorous weed growth is present, the areas have a confusing red color. The natural undisturbed areas show up as blue-gray. Grazing effects and limestone outcrops are often quite obvious. The irrigation waste run-off areas show up as scattered ribbons of red. These areas are often marshy and have thick tree and grass growth. Floodplain meadows are easily recognized due to the characteristic stream pattern and lush vegetation. The irrigated meadows usually have alfalfa planted in place of the native hay. In this area the alfalfa has a darker red color. Farm houses and buildings can be seen under high magnification. Windbreaks, gardens, and corrals commonly surround the buildings.

Differences in soil nutrients and water supply affect the density and vigor of all crops. As a result the same crop may have slight differences

from field to field. With experience and a general knowledge of farming practices, however, the interpreter can distinguish and map most of the various crops in a given area. He must, of course, consider the season in which the data were collected. The precise timing during the growing season is very important since crops may not be identifiable at certain times. As a crop matures, it may show different characteristics. Consequently, more than one set of data is desirable if unambiguous identifications are to be made. For crops in this region, three or four sets of data gathered through the growing season would probably be about optimum.

#### INTERPRETATION OF ERTS-IMAGE DENSITY CONTOUR MAPS

Density contour maps were constructed to give an enlarged presentation of the test area along with absolute film density information. The large-scale (1:19,760) density map permits accurate delineation of the contrasting fields, while the density contours allow the interpreter a means of making objective decisions about contrasts and similarities of various areas. He can also use calibrated density contour maps as a means of comparing various bands and time-sequential images. The interpreter must use these contour maps in much the same way as he would a low-altitude photograph, keeping in mind the mechanical variables as well as the natural variables (irrigation, climatology, etc.).

In this study, three time-sequential ERTS images were selected on the basis of image quality and time distribution. The red-band, 9-in. positive transparencies were chosen for time-comparison density slices. The instrument used was a Joyce Loebel/Tech Ops isodensitracer.

For control, an outline map of the crop types was constructed from the aerial photograph. The crop types were positively identified from field

## LEGEND

- C - CORN
- Bt - BEETS
- A - ALFALFA
- Gn - GRAIN (nurse crop for alfalfa)
- G - GRAIN
- Gr - GRASS/HAY
- Bn - BEANS
- Pg - PLOWED GROUND
- N - NATURAL VEGETATION
- Nw - NATURAL VEGETATION WITH IRRIGATION WATER RUNOFF
- W - WATER (tank)
- F - FLOODPLAIN (Chugwater Creek)
- Fpa - FLOODPLAIN WITH IRRIGATED ALFALFA
- H - FARM HOUSE SITE

Black outline represents fields, crop types were identified from the color infrared aerial photograph, Figure 6, and field checks.

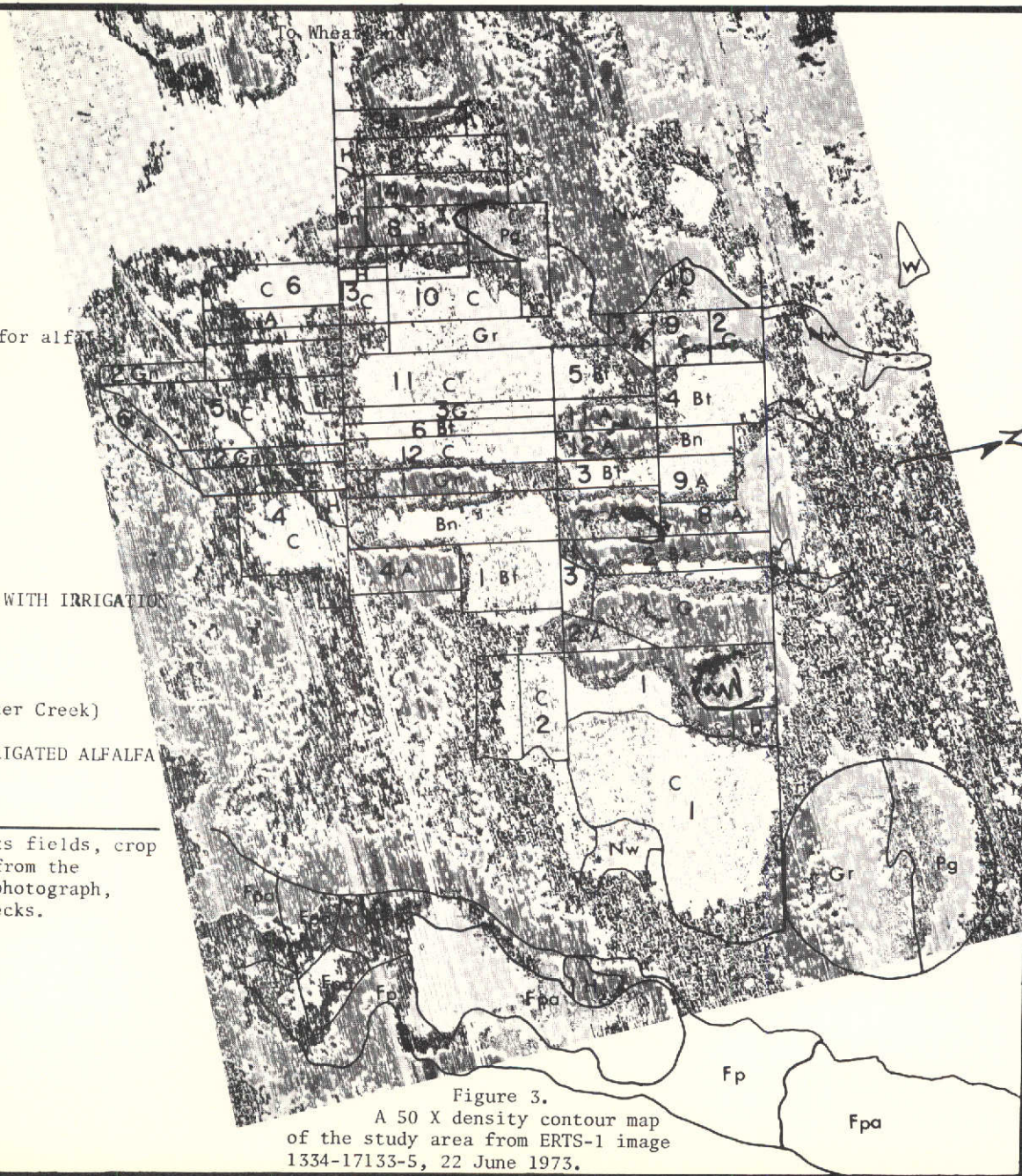


Figure 3.  
A 50 X density contour map  
of the study area from ERTS-1 image  
1334-17133-5, 22 June 1973.



## LEGEND

- C - CORN
- Bt - BEETS
- A - ALFALFA
- Gn - GRAIN (nurse crop for alfalfa)
- G - GRAIN
- Gr - GRASS/HAY
- Bn - BEANS
- Pg - PLOWED GROUND
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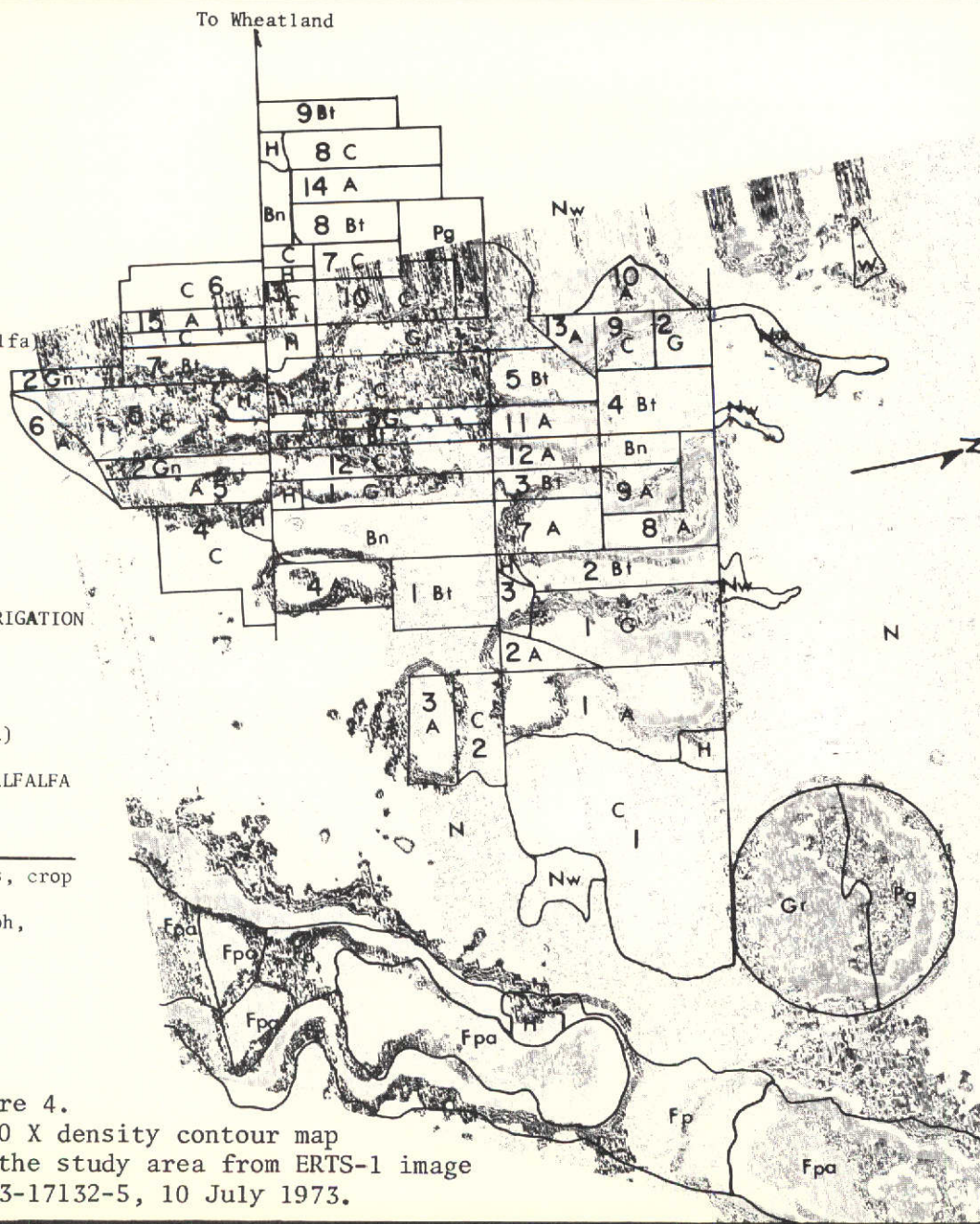


Figure 4.  
A 50 X density contour map  
of the study area from ERTS-1 image  
1353-17132-5, 10 July 1973.



C -CORN  
Bt -BEETS  
A -ALFALFA  
Gn -GRAIN (nurse crop for alfalfa)  
G -GRAIN  
Gr -GRASS/HAY  
Bn -BEANS  
Pg -PLOWED GRCDND  
N -NATURAL VEGETATION  
Nw -NATURAL VEGETATION WITH IRRIGATION  
WATER RUNOFF  
W -WATER (tank)  
F -FLOODPLAIN (Chugwater Creek)  
Fpa -FLOODPLAIN WITH IRRIGATED ALFALFA  
H -FARM HOUSE SITE

Figure 5. A 50 X density contour map of the study area from ERTS-1 image 1388-17128-5, 15 August 1973

Figure 5. A 50 X density contour map of the study area from ERTS-1 image 1388-17128-5, 15 August 1973



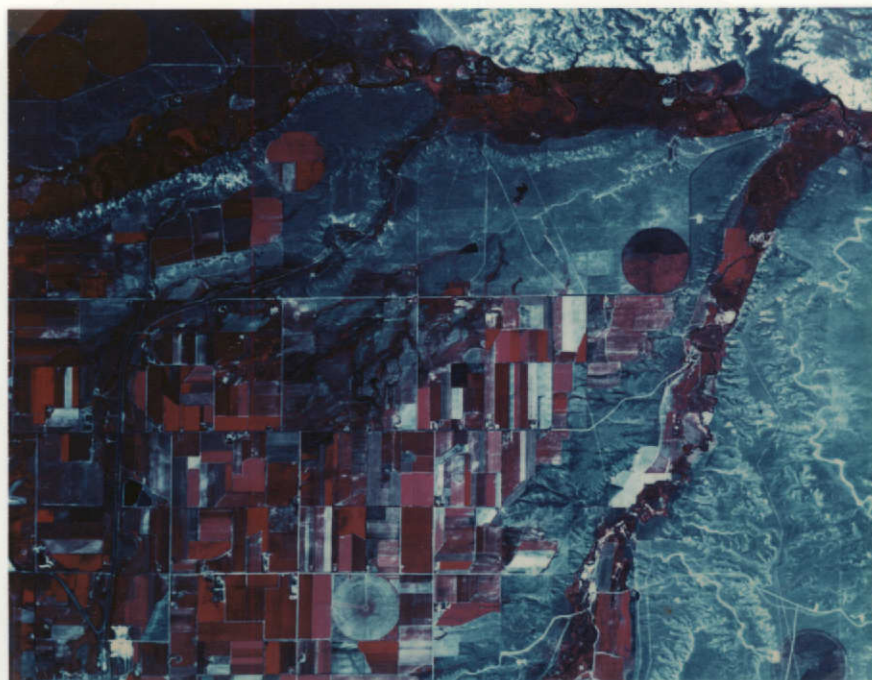


Figure 6. Color infrared aerial photograph of the Wheatland test area (taken August 9, 1973; scale 1:120,000).

checks and were the same crops throughout the summer. The settings on the microdensitometer were the same for each density contour map.

Figures 3,4, and 5 are black-and-white duplicates of the red-band isodensitracings (density contour maps). In original form, the various density patterns are displayed in color. A crop map, interpreted from a 1:120,000 color infrared aerial photograph of the area (Figure 6), has been superimposed on each of the isodensitracings.

The density contour map shown in Figure 3 was taken from ERTS-1 image 1334-17134-5, 22 June 1973. This image was taken early in the growing season and the natural vegetation areas show up dark, because of early growth of grasses and sagebrush. The corn, beans and beets are still young and show up as light areas, indicating bare soil. The alfalfa and grain crops show as darker areas suggesting various amounts of vegetative cover.

The density contour map of Figure 4, taken from ERTS-1 image 1352-17132-5, 10 July, shows the natural vegetation as lighter than in June, indicating dryer conditions or grazing pressure. The beets are darker and can be distinguished from the corn. The alfalfa and grain are generally darker than in June.

The isodensitracing shown in Figure 5, from ERTS-1 image 1388-17125-5, 15 August, shows the corn and beets as darker than before. The alfalfa in fields 4,7, and 8 is much lighter, after having been harvested. Similar observations drawn from other images and density contour maps serve as correlative data for interpretations regarding the vegetative type and condition.

An additional application of the isodensity map lies in the enhancement of boundary and mix problems. Examination of the three density contour maps (Figures 3,4, and 5) shows that large, evenly vegetated fields are

quite distinct, but, as the fields become progressively smaller or less even, or as contrast decreases, the crops become more and more difficult to map and identify. The density contour maps give the interpreter a good indication of the magnitude of this uncertainty.

## CONCLUSIONS

This study demonstrates that ERTS-1 imagery can be of considerable value in vegetation mapping and crop inventory. However, interpretation aids (such as density slicing) are helpful and seasonal data is necessary. The limiting factors in the mapping accuracy are the field size, the diversity of the crops, and the experience of the interpreter. Overall contrasts and brightness levels are related to vegetative condition.

This study confirms, in general, the results of a previous vegetative study in the Laramie Basin (Evans and Redfern, 1973). In both cases, generalized vegetative mapping was successfully accomplished by photointerpretation and density contour mapping of ERTS multispectral scanner imagery. In both cases the judgement of an experienced interpreter was an essential part of the mapping program.

## REFERENCES

- Carpenter, E. J., Fitzpatrick, E. G., Dunnewald, T. J., and Pearson, Carl, 1926, Soil survey of the Wheatland area, Wyoming; U. S. Department of Agriculture Soil Survey Reports, 1926 series, Washington, D. C. 21 p.
- Evans, M. A., and Redfern, R. F., 1973, Vegetation analyses in the Laramie Basin, Wyoming from ERTS-1 imagery; University of Wyoming, Department of Geology, Special Report, Nov. 1973, 49 p.